Chapter 27

FLOCCULANT TESTING

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ABSTRACT

Flocculant testing should be initiated for economic or performance reasons. When the decision has been made to test, the laboratory can provide valuable information concerning the various products under consideration. Properly conducted laboratory tests can determine:

1. If two flocculants are needed to achieve clarity or density.
2. Ease of mixing.
3. How quickly the material goes into solution.
4. Stability of prepared flocculant solution.
5. Stability of the floc formed.
6. Amount of mixing required for proper floc formation.
7. Optimum flocculant concentration.
8. Optimum pulp density.
9. Approximate location of the point of addition.
10. Single or multiple addition points.

When a flocculant shows promise in the laboratory, a plant test should be scheduled. During the plant trial, arrange for normal conditions and start testing with a crew that is most familiar with the unit operation where the flocculant will be applied.

INTRODUCTION

Flocculant testing should be initiated for economic or performance reasons. Also, the product currently in use could become unavailable, ore may change, or plant conditions may necessitate a new flocculant.

A more pressing reason for testing is to improve flocculant performance. In a CCD circuit, a small decrease in soluble loss or an increase in the underflow density can generate a large economic gain. In concentrate thickening, eliminating loss of solids in the overflow can be very rewarding.

If the amount of flocculant used is small, and the performance adequate, there may be insufficient economic justification for a detailed flocculant study. However, occasional settling tests with different products should not be excluded.

When large amounts of flocculant are being used, economic advantages become greater and flocculant testing should be more frequent and detailed.

Permitting flocculant representatives to test their products in the plant laboratory is an easy way to achieve required testing. A written report should be requested, and filed for future reference.

FLOCCULANT TYPES

A loose classification distinguishes flocculants from coagulants. Flocculants are generally natural or synthetic polymers available as emulsions, gels, solutions and dry powders. Most coagulants are inorganic chemicals such as lime, alum, ferric chloride, clay and similar chemicals utilized to create special conditions. Coagulants are normally used in conjunction with flocculants.

Emulsions are suspensions of a flocculant in mineral spirits, with dispersants and additives. Emulsions tend to settle out and require agitation prior to mixing with water for plant use.

Gels are in log form and require special equipment for mixing. Gel logs are simple to handle and do not cause problems with spills or dust.

The solutions are generally cationic, and may be polyacrylic acids, or polyamines. These materials may be used without prior dilution and require no hydration.

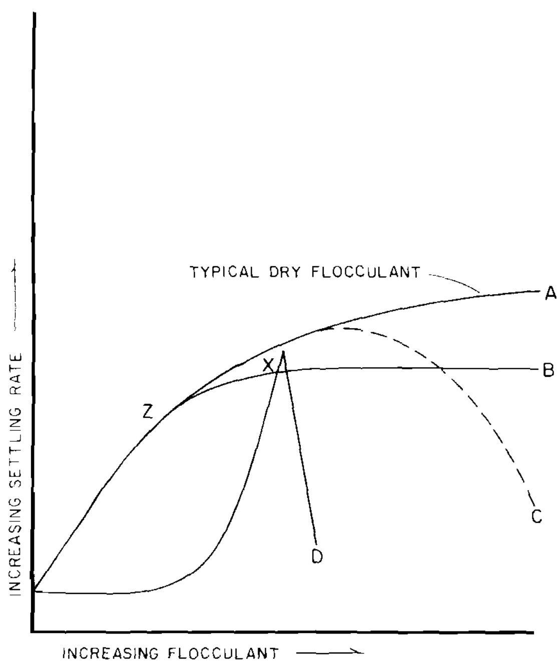
Dry polymers are generally completely active material with no additives that could interfere in other plant unit operations.

Automated mixing systems that mix the required concentration on demand from a depth gauge in the holding tank are now available for dry polymers, gels and emulsions. Automated systems can reduce the amount of operator attention required and help insure a constant concentration. If flocculant requirements are large, use of such equipment is recommended.

Flocculants react individually to each ore and each process. However, a general group of curves can be drawn as shown in Figure 1.

FIGURE I.

SETTLING CURVES



Curve A is typical of a dry flocculant and seems to be the most normal. It indicates that settling may continue at a reduced rate beyond plant requirements or economic limitations. In some cases, settling rate may decrease because of severe over-flocculation (Curve C).

Less typically, a "plateau" effect is reached as shown in Curve B. Emulsion type flocculants tend to reach a maximum settling rate and then "plateau". Increasing the amount of flocculant will not increase the settling rate.

A variation is the "peak" effect as shown in Curve D. Little or no flocculation occurs until the optimum flocculant quantity is added. A small amount of additional flocculant will result in over flocculation with a rapid decline in the settling rate. This generally occurs over a very narrow range.

For maximum effectiveness, a flocculant should satisfy plant requirements near Point Z. This gives sufficient additional increase in the settling rate to accommodate unusual plant conditions, i.e., a sudden change of ore or unusual flow rates.

If plant requirements fall near point X, more care must be used in flocculant selection. In this case, emulsion types are generally unsatisfactory because no emergency margin is available.

The uncommon "peak" effect can work only under the most intense control. At times, even automated controls fail because of over correction.

FLOCCULANT TESTING

When a new plant is built, flocculant testing must start without a comparative base. There are far too many flocculants available to run settling tests for all of them. Choose one supplier and test a range of flocculants from non ionic to high anionic with both synthetic and natural polymers. This can be done in small beakers, adding a set amount of each flocculant and determining which product creates a floc. This should eliminate all but two or three, and settling tests can then be run.

General Test Procedures

Flocculants should be mixed at a one-tenth percent solution (0.10%) for settling tests. Ease of mixing and any special conditions should be observed and noted. If the product requires special equipment, cost of this equipment must be considered in the final choice.

The complete series of tests should be conducted on the same pulp sample. The sample should have about fifteen percent (15.0%) solids. A higher percent solids may not settle readily in the cylinders and can obscure the readings. Pulp should be vigorously and continuously agitated during transfer from the bulk sample to the cylinders to insure homogeneity.

Mixing of the flocculant and pulp is critical and must be nearly identical for each series of tests. A rack holding up to four cylinders is easily constructed which allows identical mixing for each cylinder by inversion. One liter cylinders are generally used and all cylinders should be the same diameter. Results from one rack should not be directly compared to data from another rack. Mixing may vary slightly and can obscure results.

Since mixing is never perfect, samples should be added to cylinders in small increments. For example, if 600 milliliters of pulp will be used in each test cylinder and four cylinders will be filled, the following procedure is recommended.

Add 150 ml to each cylinder starting with cylinder number one. Again add 150 ml to each cylinder, but start with cylinder number two and end with number one. Continue this progression, starting with cylinder three and then four, until all 600 ml have been added. Transfer from the bulk sample to cylinders should be performed rapidly to prevent coarser solids from settling and remaining in the dipper.

Determine mixing and addition methods first. All subsequent tests - flocculant concentration, pulp density, "plateau" or "peak" effects, and combined flocculants should be conducted using the determined mixing and addition procedures.

Specific Test Procedures

Consistent test procedures are critical. The following procedures should be closely adhered to insure valid results, however, variations can be allowed for unique plant conditions.

Mixing. With four cylinders in the rack, the same amount of pulp is added to each. An amount of flocculant necessary for flocculation is added to the first cylinder and the rack inverted three times. The same amount of flocculant is then added to the second cylinder and the rack is again inverted three times. The same procedure is followed with the third and fourth cylinders and all are allowed to settle.

The first cylinder with flocculant will have been inverted twelve times, the second nine, the third six, and the fourth three times. Settling rate of the four cylinders should then be observed. The best settling rate will indicate the amount of mixing required for tests which will follow.

Settling rate will indicate optimum point of addition in the plant. If the first cylinder settled fastest, then an addition point in the launder, perhaps with baffles, is indicated. If the last cylinder (least mixed) settled the fastest, addition to the center well should be used.

Single Versus Multiple Point Addition. After required mixing is determined, conduct a test using two cylinders in the four cylinder rack to decide whether single or multiple point addition is required.

One third of the required flocculant should be added to the first cylinder and all the required flocculant to the second cylinder. The two cylinders should be inverted one third of the required inversions determined by the mixing test. The second third should be added and the cylinders again inverted one third the required number. Finally, the remaining one third should be added and the inversions completed.

Both cylinders will have received the required inversions, but the first will have had the flocculant added in increments and the second in a single dose. The settling rate should be observed to determine which method of addition will be most efficient.

Effective Flocculant Range. Tests should be run from a "starvation level" to gross over-flocculation to determine effective flocculant range. These tests are run in the four cylinders adding just enough flocculant to see floc formation in the first cylinder, the correct amount in the second cylinder, slightly over the proper dose in the third, and double the required amount in the fourth.

This test will make "plateau" or "peak" effects readily apparent. A flocculant should be rejected if either of these effects occur near the plant requirements.

Flocculant Concentration. It is often more effective to add flocculant at a lower concentration if the plant solution balance permits. A lower concentration hydrates more completely and in less time. A series of tests using different concentrations, but the same pounds per ton of solids, can be run in the four cylinders. Again, the best concentration is readily evident in the settling rate. If the solution balance does not permit lower flocculant concentration, the thickener overflow can be utilized to dilute the flocculant prior to contacting the pulp.

Pulp Density. The proper percent solids in the thickener feed can be determined in the same manner. In one of three cylinders, pulp should be added at the normal density. In the second, pulp should be diluted using an appropriate plant solution. In the third cylinder, the amount of solids should be increased. The three cylinders should be flocculated using the predetermined mixing and addition procedure while keeping a constant pounds of flocculant per ton of dry solids.

If results indicate that dilution of the thickener feed is desirable, thickener overflow can be added to the launder prior to flocculant addition with no change in the plant solution balance. In the rare case when a higher pulp is indicated, other changes in the plant may be required. As high as twenty five percent (25.0%) reduction in the required flocculant may be achieved by choosing the proper feed density.

Combined Flocculants. A combination of flocculants may be required if no single flocculant gives the required supernatant clarity or the desired underflow density. These combinations may entail the use of guar, followed by a polyacrylamide, or the use of a cationic flocculant, followed by a polyacrylamide.

Use of two separate flocculants usually requires two mixing and addition systems, but the same effect can often be reached by mixing the two flocculants. However, a cationic and anionic flocculant cannot be mixed. A precipitate will be formed and the effectiveness of one or both is destroyed.

Effects of the two flocculants can be checked in the laboratory using standard settling tests for mixing, addition, flocculant concentration, and pulp density on both the mixture and separate addition of flocculants. It may also be of value to add the polyacrylamide first, followed by the guar or cationic polymer.

Vary the ratio of the two, i.e., 25 to 75 percent, 50 to 50 percent, and 75 to 25 percent. If a combination is required, one that is most advantageous economically should be selected.

FLOCCULANT SELECTION

When testing different flocculants, the same economic amount must be used and not necessarily the same pounds per ton. Using twice the quantity of a flocculant which is half the cost of another will give a fair economic comparison.

Some flocculants do not tolerate prolonged mixing or pumping. This may be checked in the laboratory by mechanically mixing the solution for twenty four hours and comparing the settling rate with a solution that has undergone normal mixing.

MIXING AND STORAGE

Guar flocculants are subject to bacterial degradation. Tanks for mixing and storing guar solutions should have a bottom drain to permit complete use of the solution before more is added.

All flocculant tanks should have a curved bottom with a center drain. No flocculant is completely soluble and solids that settle to the bottom and can eventually work into the system. These solids can plug lines or interfere with measuring instruments.

After all laboratory tests have been completed and an acceptable flocculant found, the settling tests should be repeated after a minimum of forty eight hours. Ore variations, reagent changes in other parts of the plant, different grind, and many other factors may effect flocculant efficiency. If the second series of tests confirm data from the first, the flocculant is ready for plant testing.

PLANT TESTING

When a flocculant shows promise in the laboratory, a plant test should be scheduled. Sufficient flocculant should be received for several weeks of testing to allow for variations in the ore or plant operation. The flocculant supplier's technical representative should be present during the initial plant trial phases to advise of unusual mixing or handling problems.

Plant mixing equipment must be adequate for the amount of time required to solubilize the flocculant. If the flocculant does not go completely into solution, effectiveness will be reduced. More flocculant will be required which further reduces the available mixing time. This concatenation will eventually spiral to a disastrous conclusion to the test.

The following changes in plant operation should be made prior to testing:

1. Using the laboratory data, the correct points of addition should be installed.
2. Necessary piping changes should be made for flocculant dilution prior to contact with the pulp if plant equipment is not large enough to mix the desired concentration.
3. If a lower density is desireable, dilution of the thickener feed should be arranged.
4. It is imperative that plant conditions remain as normal as possible during the trial.
5. Testing should be started with a crew that is most familiar with the unit operation where the flocculant will be applied. All crews should be advised of the improved performance expected and monitor these data reporting any unusual aspects of the operation.
6. Several variations should not be tested simultaneously or none of the data will be valid.

A thickener operating instruction chart based on several years experience has been included. Operating data and variations in plant performance will be easier to evaluate if all crews follow this procedure. This chart is also a valuable training tool for new operators.

The performance of the new flocculant can be monitored by torque level readings, slime level position, and underflow density. A simple slime pole is effective for determining changes in the slime level. Most thickeners are equipped with a torque meter of some type and a density cup will determine the underflow solids.

Unfortunately, by the time these indicators have detected problems the thickener may be in serious trouble. If an incorrect amount of flocculant has been added, the thickener will be almost full of improperly flocculated material. This can take as long as twenty four hours to correct.

To ensure proper flocculation is occurring, a sample should be dipped from the center well and the settling rate observed. This will allow adjustment of the flocculant rate before the thickener is full of improperly flocculated pulp. Acceptable settling rate should be determined by plant experience. One inch in three minutes is generally adequate if the thickener is properly sized. Center well sampling should be a part of normal procedure to allow operators to detect unexpected ore changes, flow rate variations, or flocculant system malfunctions.

Plant operations should return to the original flocculant for several weeks after the initial test period with a new flocculant. This will allow comparison of data before and after the trial; changes initiated for the plant trial may increase efficiency of the original flocculant. It will also allow the original flocculant stock to be depleted and provide time for more flocculant to be delivered.

One final note of caution. Despite the best laboratory testing, the new flocculant may prove to be unsatisfactory. In the purchase order for test material specify that any remaining material may be returned for credit if the plant test proves unsatisfactory.

CONCLUSION

Complete laboratory evaluations should be conducted prior to starting any plant trial. A bad laboratory settling test can simply be poured down the drain; a bad plant trial may require several days to be completely corrected.

Flocculant testing can be an easy way to decrease operating costs without major capital expenditure. Be aware of new products or procedures that may increase efficiency or reduce operating costs.

THICKENER OPERATING INSTRUCTIONS

IF			DO THIS	
SLIME LEVEL	TORQUE	U'FLOW DENSITY	PUMP RATE	FLOCC.
→	→	→	→	→
↗	→	→	↗	→
↗	↗	→	↗	→
↗	→	↘	↘	↗
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